2 Outline of Ultra-Realistic Communication Research

INOUE Naomi

NICT is conducting research on Ultra-realistic communication since April in 2006. In this research, we are aiming at creating natural and realistic communication with people in remote places as if they are being there. For this research, we are studying 3D image technologies, 3D sound technologies, multisensory interfaces and also developing more objective measurement/evaluation technique of feeling “presence” by using brain image and psychophysics. All of research results on Ultra-realistic communication are collected and published in this special issue. Preceding technical articles, outline of Ultra-realistic communication research is introduced in this section.

Keywords
Ultra-realistic communication, 3D image technology, 3D acoustic technology, Multisensory interface, Objective measurement/evaluation technique

1 Introduction

When various people try to communicate, conceivable inhibitors to those attempts include differences in language, culture, values, knowledge, experience, and physical abilities. To make a society with ubiquitous computing a reality in the future, it is indispensable to create technologies that can break these barriers. As a result, expectations run high for realizing a new form of barrier-free communication, that is, “universal communication.”[1]

In April 2005, the Ministry of Internal Affairs and Communications (MIC) established the “Investigation Society Regarding Universal Communication Technology” as a place for organizing and considering the concepts and future images of universal communication, the R&D challenges and actions regarding research toward realizing such technology, and other issues. This investigation society later compiled the results of its considerations in the form of a report[1] issued in December 2005. The report cites research and development in “ultra-realistic communication technology” toward realizing realistic communication with people in remote areas as one of the technical challenges in making universal communication a reality. In response to that report, it was decided that the National Institute of Information and Communications Technology (NICT) would conduct studies on ultra-realistic communication technology, in line with its five-year plan starting in April 2006.

2 What is ultra-realistic communication technology?

Through its research and development in “ultra-realistic communication,” NICT intends to realize natural and realistic communications where people can share the same space with others in remote locations as if they were “on-site” together. To that end and with the catchphrase of “See, Hear, Touch and Smell-Creating an Ultra-Realistic Environment around

You” as shown in Fig. 1, NICT decided to promote research and development in element technologies such as 3D image technology, 3D sound technology, multisensory interface technology that presents smell and haptic information in a manner integrated with images and sounds, technology for quantitatively measuring and evaluating realistic sensations experienced by people, and elucidation of the perceptual and cognitive mechanisms for experiencing realistic sensations. As shown in Figs. 1 and 2, NICT has been making these R&D efforts for the past five consecutive years. The establishment of these technologies is also expected to enable their use in a wide range of applications, including 3D broadcasting, a 3D image communication system, communication conferencing systems based on multi-sensory information, surgical simulations and other medical systems, digital signage, and other applications.

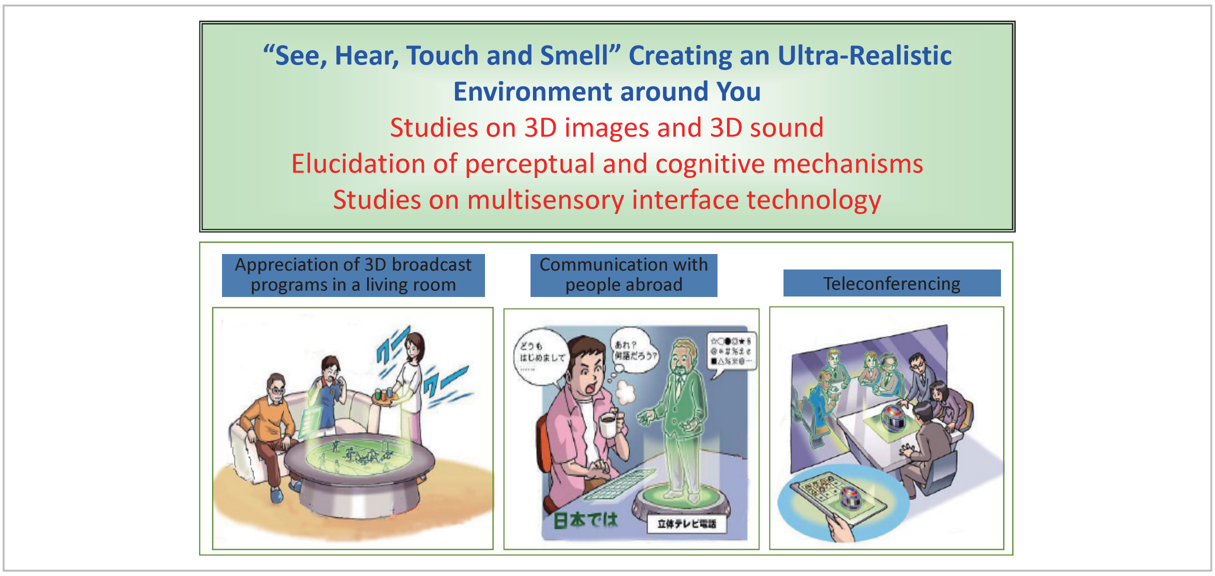

Fig.1 *Overview of ultra-realistic communication*

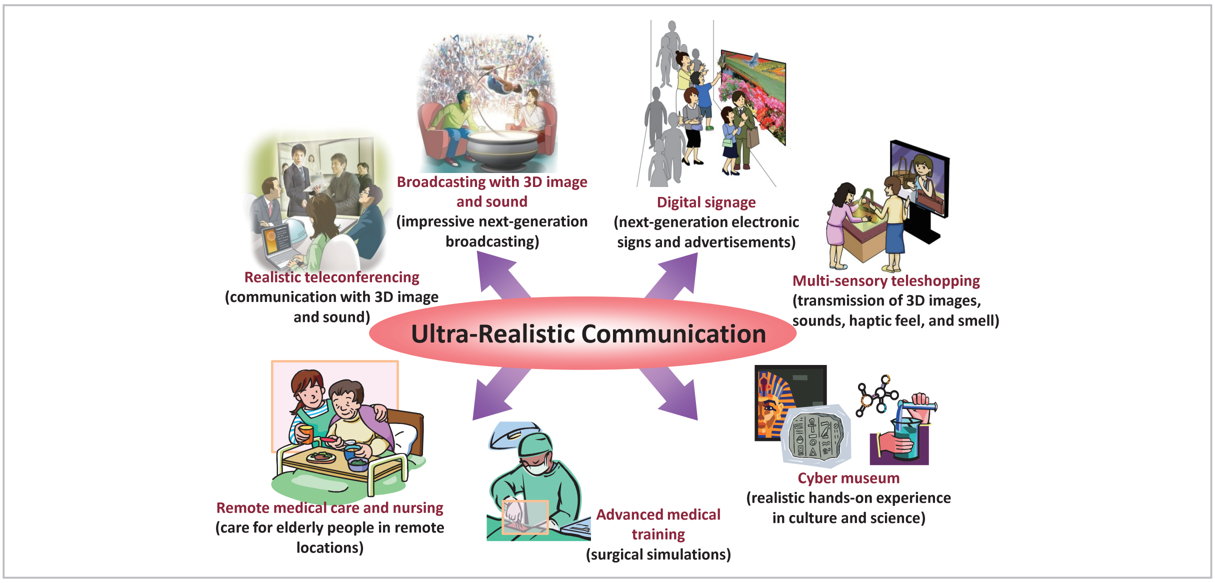

Fig.2 *Applications of ultra-realistic communication technology*

3 Research resources and research items

It was decided that research and development in ultra-realistic communication would be conducted at the Universal Media Research Center established by NICT in April 2006. This research center has two groups: the 3D Spatial Image and Sound Group and the Multimodal Communication Group. The first research group reproduces information about remote locations on this site with physical fidelity. The group has been researching and developing electronic holography—an ultimate 3D image technology that even universities find difficult to tackle—along with research and development in 3D sound technology based on wave field synthesis, in order to reproduce a 3D sound field in space. The second research group has conversely been building the prototype of an ultra-realistic communication system and evaluating realistic sensations experienced by people, in an attempt to develop technology for generating realistic sensations optimized for people, and because it is considered possible to cause people to experience realistic sensations without reproducing information on a remote location with fidelity. For that reason, the group has also been conducting research and development by taking engineering approaches (via 3D image technology, 3D sound technology, and sensory interface technology) and the human scientific approaches of evaluating and measuring realistic sensations experienced by people based on human perceptual and cognitive mechanisms as elucidated through brain activity measurements and psychophysical experiments. With these two series of research combined organically, the group has been establishing the prototype for a "people-optimized" ultra-realistic communication system.

3.1 Efforts made by the 3D spatial image and sound group

The 3D Spatial Image and Sound Group has been researching and developing 3D image technology in an attempt to reproduce information about remote locations with physical fidelity. For 3D image presentation technology (as listed in Table 1), various systems have already been proposed[2]. On the other hand, there are

Table 1 *Various systems for 3D image presentation*

System		Characteristics
Binocular parallax system	Stereoscopic system	This requires equipment for displaying one set of images (left and right). The methods available include one based on glasses (separation by color and polarization), one not based on glasses (lenticular lens, parallax barrier), and one based on HMD.
	Autostereoscopic system	By using a lenticular lens, parallax barriers and other means, this method forms three or more viewpoints. For that reason, glasses are usually unnecessary. Here, we have the effect of a motion parallax.
Integral imaging system	High-concentration autostereoscopic system (ultra autostereoscopic system)	By forming even more viewpoints, this system gives the effect of a motion parallax that changes smoothly. This also enables an integral imaging method, instead of the formation of viewpoints.
	Integral photography system	A fly-eye lens is used for pickup and display to reproduce a parallax not only horizontally but also in all directions. Moreover, it reproduces a group of light rays, so as to generate natural 3D reproduced images.
	Holography	It reproduces the light wave from an object, thereby accurately recording and reproducing 3D image information sent from the subject. This requires laser lighting or other coherent light.
Volumetric system	Layered screen type, rotary screen type, etc.	By displaying image on multiple layered transparent screens, displaying image on a rotary screens in time divisions, and other means, this system expresses 3D images in a constant volume. Although subject to the constraints of displayed space, this system is characterized by its ability to reproduce images at actual depth locations.

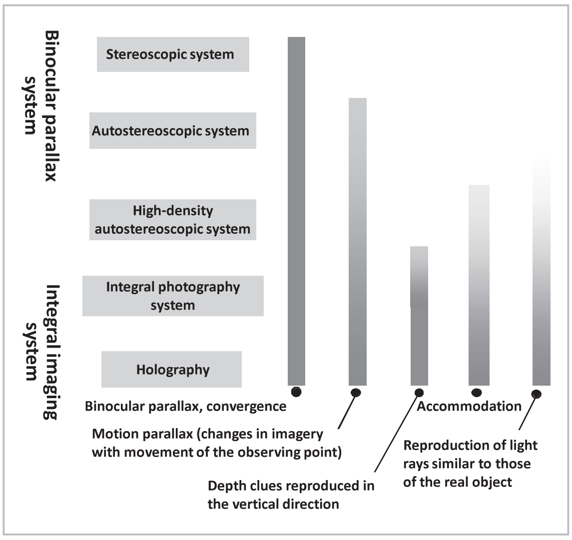

Fig.3 *Relation between the presentation system and depth recognition clues*

four known physiological clues for people to recognize the depth of an object and see it in 3D form: accommodation, convergence, binocular parallax, and motion parallax. Figure 3 shows the relation between the existing 3D image presentation system and these four kinds of information reproducibility.

As shown in Fig. 3, holography is the only system that completely reproduces the four kinds of information (i.e., accommodation, convergence, binocular parallax, motion parallax) that humans use as clues to depth recognition. For that reason, a 3D image reproduced by holography is both natural and allows people to see things as if the real object were there. The 3D Spatial Image and Sound Group is thus committed to researching and developing electronic holography.

In addition to image technology, there is another technology for sound technology called wave field synthesis, which entails reproducing a 3D sound field by controlling the sound pressure at many points in space by using the Kirchhoff-Hemholz formula that describes “the propagation of sound through the air” quantitatively. As for the technology to reproduce a sound source at a remote location, the group is also committed to researching and developing such technology.

3.2 Efforts made by the multimodal communication group

As an example of an ultra-realistic communication system, one can assume a situation where people in Japan can buy pottery in an open-air market held on a street corner in Paris. As such, for people to communicate with others in a remote location as if they were there, it seems necessary to generate “a place and an atmosphere” (so that you feel as if you were in Paris), the “presence of people” (so that store clerks can engage in natural conversations with you as if they were there), and “a feel of operating objects” (so that you can pick up and inspect products). The Multimodal Communication Group thus classified information to be conveyed into three categories (“a place and an atmosphere,” “presence of people,” and “a feel of operating objects”) and has been conducting research on the constituent technologies (i.e., 3D image technology, 3D sound technology, multi-sensory interface technology) according to these classifications. With regard to 3D image technology, for example, the group corresponded “a place and an atmosphere,” “presence of people,” and “a feel of operating objects” to the distance from viewers, and has been researching and developing technologies for each classification to present “far,” “near,” and “close-at-hand” images. More specifically, the group has been researching and developing large-screen, glasses-free 3D displays large enough to display people in life-size images for “far” and “near” images, as well as researching and developing handheld-box-type and tabletop glasses-free 3D displays. These 3D image technologies are based on the “high-density autostereoscope (super autostereoscope)” and “integral photography” systems as listed in Table 1. Although it is not currently possible to reproduce the depth clues of humans as accurately as holography, the present technical level allows a buildup of systems better than holography in terms of image resolution and width of the visible range reproduced. The group has therefore been working on these technologies as part of the prototype ultra-realistic communication system. Moreover, since 3D sound technology is known in the form of various versions, each one still has something on the way to develop, thereby making it necessary to take various measures including the development of necessary technology when considering such practical use environments as one not dependent on the viewing position or the reproduction environment (including differences among individuals). As these base technologies, the group is working on simulation technology that will enable a precise and large-scale determination of sound pressure distribution. Moreover, for haptic sense and olfactory display technologies, the group has been developing unprecedented new display devices, as well as researching and developing multisensory interaction systems that integrate these kinds of information without a sense of discomfort, for systems that operate objects “close at hand.” Moreover, in proceeding with such research, the group has been conducting research not only by taking engineering approaches, such as research on 3D images, 3D sound technology, and haptic and olfactory display devices, but also elucidating the perceptual and cognitive mechanisms of humans through brain activity measurements and psychophysical experiments, thereby conducting research by taking human scientific approaches that entail evaluating and measuring realistic sensations experienced by people. Both series of studies have been organically combined (as shown in Fig. 4) to build the prototype of a “human-optimized” ultra-realistic communication system.

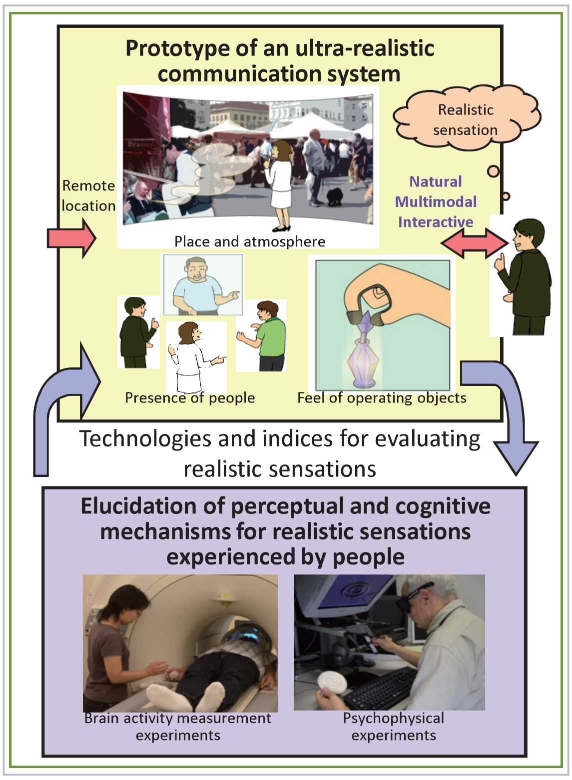

Fig.4 *Contents of research by the Multimodal Communication Group*

4 Conclusion

This paper presented the fact that the Universal Media Research Center has been conducting research on ultra-realistic communication since April 2006. It specifically positioned, presented, and gave an overview of the research being conducted on ultra-realistic communication. The paper then described the two research groups conducting this research, and presented the efforts made by each group. For details, please refer to Chapters **3**, **4**, **5** and **6**.

Chapter **3** described the 3D image technology, while Chapter **4** presented the research results of 3D sound technology. Chapter **5** described the multisensory integration technology and evaluation technology for realistic sensations experienced by people. Last but not least, Chapter **6** presented the standard test content produced in order to support the publicizing of 3D images and the results of demonstrative experiments conducted thus far.

References

1 Study Group on Universal Communications Technologies (Leader: Dr. Hiroshi Harashima), final report, http://www.soumu.go.jp/s-news/2005/pdf/051215_3_2.pdf

2 Susumu Tachi, Makoto Sato, Michitaka Hirose, "Lectures of Virtual Reality," Virtual Reality Society of Japan(Ed.), Kogyo Chosakai Pubulishing, Inc., 2010

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INOUE Naomi, *Ph.D.*

Executive Director, Universal Media Research Center

Human Machine Interface